PATTERN INSPECTION METHOD AND APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a method and apparatus for fabricating substrates having circuit patterns such as semiconductor devices and liquid crystal display devic es, and more particu larly to a technique of inspecting substrate patterns in fabrication process.

Description of the Related Art

Conventional optical or electron-beam pattern inspection apparatuses have been proposed in JP-A Nos. H5 (1993) – 258703, H1 1 (1999) – 160247, S61 (1986) – 278706, H7 (1995) – 5116, H2 (1990) – 146682, H9 (1997) – 312318, and H3 (1991) – 85742, for example.

Referring to FIG. 1, there is shown an examp le of a configuration of an electron-beam pattern inspection apparatus, which is disclosed in JP-A No. H5 (1993) – 258703. In this conve ntional electron-beam pattern inspection apparatus, an electron beam 2 emitted from an electron source 1 is deflected in the X direction by a deflector 3, and the electron beam 2 thus deflecte d is applied to an object substrate 5 un der test through an objective lens 4. Simultaneous ly, while a stage 6 is moved continuously in the Y direction, secondary e lectrons 7 or the like produced from the object substr ate 5 are detected by a detector 8. Thus, a detected

analog signal is out put from the detecto r 8. Then, through an A/D converter 9, the detected analog signal is converted into a digital image. In an image processo r circuit 10, the digital image thus pro duced is compared with a refere nce digital image whic h is expected to be ide ntical thereto. If any dif ference is found, the difference is judg ed to be a pattern defect 11 and a location thereof is determined.

Referring to FIG. 2, there is shown an examp le of a configuration of an optical pattern inspection apparatus, which is disclosed in JP-A No. H11 (1999) - 16 0247. In this conventional optical in spection apparatus, a light beam emitted from a light source 21 is applied to an object substrate 5 under test through an objective lens 22, and light reflected from the object substrate 5 is detected by an imag e sensor 23. While a stage 6 is moved at a constant speed, detection of reflected light is repeated to produce a detected image 24. The detecte d image 24 thus produced is sto red into a memory 25. On the memory 25, the detected image 24 is compared with a previously memor ized reference image 27 which is expected to have a pattern identical to that of the detecte d image 24. If the pattern of the detected image is identical to tha t of the reference image 27, it is judged that ther e is no defect on the object substrate 5. If these patterns are not ide ntical to each other, a pattern defect 11 is recogni zed and a location thereof is determined . As an example, FIG. 3 shows a layout of a wafer 31 corresponding to th e object substrate 5.

On the wafer 31, there are formed dice 32 whi ch are to be separated

eventually as individual identical products. The stage 6 is moved along a scanning line 33 to detect images in a stripe region 34. In a situation where a detection position A 35 is currently taken, a pattern image attained at the detection position A 35 is compared with a pattern image attained at a detection position B 36 (reference pattern image 27), which has been stored in the memory 25. Thus, each pattern image is compared with a reference pattern image which is expected to be identical thereto. In this arrangement, the memory 25 has a storage capacity sufficient for retaining reference pattern image data to be used for comparison, and the circuit structure of the memory 25 is designed to perform circular-shift memory operation.

In the following two examples, a defect check is conducted using a binary image of an object under test. In synchronization with pattern detection, a judgment is formed on whether a pattern of the object is defective or not while ignoring a possible defect in a particular mask region.

In JP-A No. S61 (1986) - 278706, there is disclosed an example of a technique of inspecting through-holes on a printed circuit board. In this inspection technique, a printed circuit board having through-holes only in a non-inspection region thereof is prepared beforehand, and an image of the printed circuit board is taken prior to inspection. A binary image indicating the presence/absence of through-holes is thus attained for masking, and it is stored as image data in masking data storage. At the time of inspection, if a difference

found in binary image comparison is located at a position included in a mask region stored in the masking data storage, the difference is ignored for non-inspection.

In JP-A No. H7 (1995) - 5116, there is disclosed an example of a technique for printed circuit board inspection. In this inspection technique, a pattern is detected to provide binary image data, and using the binary image data, a judgment is formed on whether the detected pattern is normal or not; more specifically, it is checked whether the detected pattern meets any specified regular pattern or not. If not, the detected pattern is judged to be defective.

In the following two examples, using pattern data, a dead zone is provided for the purpose of allowing an error at a pattern boundary in inspection.

In JP-A No. H2 (1990) - 146682, there is disclosed an example of an inspection technique in which a mask pattern is compared with design data. Through calculation of design data, a pattern is reduced by a predetermined width to attain a reduced image and also the pattern is enlarged by a predetermined width to attain an enlarged image. Then, a part common to the reduced image and the enlarged image is extracted to provide a dead zone having a certain width. Thus, using the design data, a mask region is provided so that an error at a pattern boundary having a certain width will be ignored in inspection.

In JP-A No. H9 (1997) - 312318, there is disclosed an example of a technique of inspecting patterns using a scanning electron microscope

(hereinafter referred to just as a "SEM"). Using a referenc e image acquired in advance, a vicinal area of a pattern edge is set up as a region where no critical defect occurs since a minuscule deviation of a pattern edge is not regarded as a defect. Thus, an image of the region where no critical def ect occurs is ignored . If any difference is found between the reference image and an image of a pattern under test ex cluding the region where no critical defect occurs, the difference is judged to be a pattern defect.

In JP-A No. H3 (1991) - 85742, there is di sclosed an example of a system for carrying out comparative inspection of printed circuit patterns. An image of a candidate def ect attained in com parative inspection is stored in memory. Then, not simultaneously wi th the comparative inspection, the memorized image is examined to judge whether a difference is actually a defect or not.

On an object under te st, there is an area where a considerable difference is found in comparative inspection of patterns even if the difference is not act ually a defect. For example, on an ion-im planted region for formation of a transistor, a non-defective difference may be found in comparati ve inspection of patt erns. Although a difference between a part where ions have been implan ted and a part where ions have not been implanted is important at a locat ion of a transistor element, the characteristics of wiring areas ot her than transistor element locations are not affected by the presence/absence of implanted ions. Therefore, in an ion implantation process, rough masking is used to

determine where ions are to be implanted. However, in elect ron-beam inspection of wiring areas, a considerabl e difference attribu table to whether implanted ions are present or not may be detected, resulting in a wrong judgment indicating that the difference represents a defect.

Further, for example, in a power line layer where redundant wiring is made, even if a part of wiring is not connected, circuit no rmality can be ensured by pro viding a connection at another point. Therefore, in some cases, rough patterning is made for power wiring arrangement, so that no-connecti on pattern elements are left. In com parative inspection of detected images, a difference attributable to whether a connection is provided or not may be found, resulting in a wrong judgment indicating that the difference represents a defect.

Still further, for ex ample, on a pattern ed ge, a detected signal level varies dependin g on the thickness/in clination of a film thereof. Although up to a cert ain degree of variati on in detected signal output may be ignored, a considerable difference in detected signal output is likely to be taken as a defect mistakenl y. A degree of fals e defect detection is however applicable as an index representing product quality. It is desirable to exam ine the degree of false defect detection and preclude false defects before carrying out defect inspection.

In the conventional optical/electron-beam pattern inspection apparatuses disclosed in JP-A Nos. H5 (1 993) - 258703 and H1 1 (1999) - 160247, it is not allowed to set up a non-inspection region.

In the inspection tec hniques disclosed in JP-A Nos. S61 (1986)

- 278706 and H7 (1995) - 5116, there is prov ided a non-inspection region. However, according to an example presented in JP-A No. S61 (1986) - 278706, it is required to spe cify a non-inspection region covering a ve ry large area by using a bit pattern. In applicatio n to wafer inspection, a wafer surface area 300 mm in diameter has to be inspected using pixe ls each having a size of 0.1 μm. This requires an impractically large number of pixels, i.e., seve n tera-pixels (seven terabits). Accordin g to th e inspection technique disclosed in JP-A No . H7 (1995) - 5116, any areas other than regular pa ttern areas are treat ed as non-inspection regions. Since very complex patterns are formed on a wafer, a non-inspection region cannot be set up just by means of simple pattern regularity.

In the inspection techniques disclosed in JP-A Nos. H2 (1990) - 146682 and H9 (1997) - 312318, the use of a non-inspection region is limited to a pattern edge, and therefore it is not allowed to set up a non-inspection region at an arbitrary desired location.

In the inspection sys tem disclosed in JP-A No. H3 (1991) - 85742, image data of a candi date defect is stored , and then detail ins pection is carried out using the stored image data to check whether a difference is actually a defect or not. This approac h is applicable to in spection of complex pattern geometries. However, ba sed on predetermined criteria, a judgment is formed on whether a differ ence is actually a defect or not. Any part may be judged to be normal if requirements base d on the predetermined criteria are satisfied. Th at is to say, once a part is judged to be normal, data regarding the part will be lost.

As described above, in the conventional pattern inspection techniques, it is not allowed for a user to set up a non-inspection region effective for a device having a complex, large pattern area to be inspected such as a wafer. Further, in cases where a considerable difference is found in comparative inspection of detected images even if the difference is not actually a defect, it is likely to be misjudged that the difference represents a defect. In addition to these disadvantages, the conventional pattern inspection techniques are also unsatisfactory as regards stability in detection of minuscule defects.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to overcome the above-mentioned disadvantages of the prior art by providing a pattern inspection method and apparatus for enabling a user to easily set up a non-inspection region effective for a device having a complex, large pattern area to be inspected.

In accomplishing this object of the present invention and according to one aspect thereof, there is provided a pattern inspection apparatus such as shown in FIG. 4. While an exemplary configuration of an electron-beam pattern inspection apparatus is presented here, an optical pattern inspection apparatus can be configured in the same fashion in principle. The electron-beam pattern inspection apparatus shown in FIG. 4 comprises an electron source 1 for emitting an electron beam 2, a deflector 3 for deflecting the electron beam 2, an objective lens 4

for converging the electron beam 2 onto an object substrate 5 under test,
a stage 6 for holding the object substrate 5 and for scanning/posi tioning
the object substrate 5, a detector 8 for detecting secondary electrons
7 or the like produce d from the object sub strate 5 to output a detected
analog signal, an A/D converter 9 for converting the detected analog
signal into a digital image, an image processor circuit 10 in which the
converted digital image is compared with a reference digital image
expected to be identical thereto and a difference found in comparison
is indicated as a can didate defect 40, a candidate defect memo ry part
41 for storing featu re quantity data of each candidate defect 40 such
as coordinate data, projection length data and shape data, a mask setting
part 44 in which patte rn defects 11 stored in the candidate defec t memory
part 41 are examined and a candidate def ect located in a mas k region
42 (shown in FIG. 5) prespecified with coordinates is flagged as a masked
defect 43 (shown in FIG. 5), and an operat ion display 45 on whi ch data
of pattern defects 11 received from the mask setting part 44 is dis played,
an image of a selected pattern defect 11 is displayed, and the mask region
42 is displayed or edited.

The following describes operations in the electron-beam pattern
inspection apparatus configured as mentio ned above. Referring now to
FIG. 5, the mask region 42 is described below.

On the object substra te 5, there is an area where a considerable
difference is found in comparative inspection of patterns even if the
difference is not act ually a defect, such as a region 50 where ions have

been implanted. In practice of ion impl antation, ions are likely to be implanted in a deviated fashion, i.e., a deviated ion-implanted 'part 52 is formed besides normal ion-implanted pattern parts 51. The deviated ion-implanted part 52 has no adverse effec t on device character istics, i.e., the deviated ion-implanted part 52 should be judged to be non-defective. Howe ver, the deviated ion-implanted part 52 is detected as a pattern defect 11 . Therefore, an area including the ion-im planted region 50 is set up as a mask region 42, and a possible defect in the mask region 42 is treated as a masked defect 43. Since the same die pattern is formed rep etitively on the wafe r 31 shown in FIG. 3, on-die coordinates are used in region recogniti on. Parts having the same coordinates on different dice are regarded as identical, and if on-die coordinates of a part are included in a specified region, it is regarded that the part is incl uded in the specifie d region. For the wafer 31, beam shots are also characterized by repetitiveness besides dice. Each shot is a unit of beam exposure in a pattern exposure system used for semiconductor device fabrication. For identifying some kinds of false defects to be preclud ed in pattern inspect ion, the use of shots may be more suitable than that of dice with respect to pattern repetitiveness. Although the following description handles dice, it will be obv ious to those skilled in the art that shots are ap plicable in lieu of dice and that there may be provi ded an arrangement for allowing a changeover between shots and dice.

Operations in the el ectron-beam pattern inspection apparatus

according to the present invention include a conditioning operation in which the mask region 42 is defined and an inspection operation in which any candidate defect 40 detected in other than the mask region 42 is judged to be a pattern defect.

In the conditioning operation, the mask region 42 is cleared, the electron beam 2 emitted from the electron source 1 is deflected in the X direction by the deflector 3, and the electron beam 2 thus deflected is applied to the object substrate 5 through the objective lens 4. Simultaneously, while the stage 6 is moved continuously in the Y direction, secondary electrons 7 or the like produced from the object substrate 5 are detected by the detector 8. Thus, a detected analog signal is output from the detector 8. Then, through the A/D converter 9, the detected analog signal is converted into a digital image. In the image processor circuit 10, the digital image thus produced is compared with a reference digital image which is expected to be identical thereto. If any difference is found in comparison, the difference is indicated as a candidate defect 40. Feature quantity data of each candidate defect 40 such as coordinate data, projection length data and shape data (image data) is stored into the candidate defect memory part 41. In the mask setting part 44, pattern defects 11 are set using feature quantity data of respective candidate defects 40. The pattern defects 11 are superimposed on an image of the object substrate 5, and the resultant image is presented on a map display part 55 of an operation display 45 (screen) shown in FIG. 6. The user can select any one of the pattern

defects 11 (includin g true defects 57 an d false defects 58 not to be detected in FIG. 6) on the map display par t 55 of the operation display 45. An image of a pa ttern defect 11 sele cted on the map disp lay part 55 is presented on an image display part 56 of the operation display 45. By checking the image of each of the pattern defects 11 on the image display part 56, the user classifies the pattern defects 11 into true defects 57 and false defects 58 not to be detected. The results of this classification are indicated as particular symbols on the map display part 55.

After completion of the defect classificat ion mentioned above, the user selects an operation display screen shown in FIG. 7, which comprises a map display part 55 for presenting an enlarged map including true defects 57, false defects 58 not to be detected and a current position indicator 59, and an image display part 56 for presenting an image corresponding to the current position indi cator 59. On the map display part 55, the user can specify a mask region 42 and check a position of each pattern defect 11. With reference to classification info rmation on each pattern defe ct 11 and the image corresponding to the current position indicator 59, the user sets up coordinates of a mas k region 42 so that the false defects 58 will not be detected. As required, the user carries out the co nditioning operation again to set up the coor dinates of the mask region 42 more accurately.

In the inspection operation, the electron beam 2 emitted from the electron source 1 is deflected in the X direction by the de flector

3, and the electron beam 2 thus deflected is applied to the object substrate 5 through the object ive lens 4. Simultan eously, while the st age 6 is moved continuously in the Y direction, secondary electrons 7 or the like produced from the ob ject substrate 5 are detected by the det ector 8. Thus, a detected ana log signal is output from the detector 8. Then, through the A/D converter 9, the detected analog signal is converted into a digital image . In the image proce ssor circuit 10, the digital image thus produced is compared with a reference digital image which is expected to be id entical thereto. If any difference is found in comparison, the difference is indicated as a candidate defect 40. Feature quantity data of each candidate defect 40 such as coordinate data, projection length da ta and shape data (im age data) is stored into the candidate defect mem ory part 41. The fe ature quantity data of each candidate defect 40 is examined to judge whether the candidate defect 40 is located in the specified mask region 42 or not. If it is determined that the candidate defect 40 is not located in the specified mask region 42, the candidate de fect 40 is defined as a pattern defect 11. Then, the pattern defect 11 is superimposed on an image of the object su bstrate 5, and the resultant image is presented on the map display part 55 . Eve n if the candidate defect 40 is not defined as a pattern defect 11, the feature quantity dat a thereof is retaine d so that it can be displayed again. This makes it possible for the user to avoid forming a wrong judgment that a considerable non-defective difference is a defect.

In the above-mentione d arrangement of the present invention, the

mask setting part 44 is used for determining a false defect not to be detected. While coordinates are used in the mask setting part 44 as exemplified above, any other pattern data or feature quantity data of each candidate defect image is also applicable for identification. On a pattern edge, a degree of variation in detected signal output does not depend on coordinates, and therefore pattern-edge feature quantity data is used for identification instead of coordinate data.

Further, while masking is made for non-inspection of candidate defects as exemplified above, another inspection means or a method of inspection based on another criterion is also applicable to examination of an area corresponding to a mask region. In this case, according to conditions specified by the user after inspection, a defect judgment can be formed again regarding candidate defects 40 stored in the candidate defect memory part 41.

As described above and according to the present invention, the user can set up a non-inspection region effective for a device having a complex, large pattern area to be inspected such as a wafer. Further, in cases where a considerable difference is found in comparative inspection of detected images even if the difference is not actually a defect, the present invention makes it possible to avoid false defect detection while carrying out detection of minuscule defects.

These and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the

accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front view showing a schematic configuration of a conventional electron-beam pattern inspection apparatus;

FIG. 2 is a front view showing a schematic configuration of a conventional optical pattern inspection apparatus;

FIG. 3 is a plan view showing a layout of a wafer;

FIG. 4 is a front view of an electron-be am pattern inspectio n apparatus, showing an arrangement of first problem-solving means according to the present invention;

FIG. 5 is a plan view for explaining operation of the first problem-solving means according to the present invention;

FIG. 6 is an explana tory diagram showing a layout of a defec t check screen;

FIG. 7 is an explanato ry diagram showing a layout of a mask region setting screen;

FIG. 8 is a front view showing a configuration of an electron-beam pattern inspection apparatus in a first preferred embodiment of the present invention;

FIG. 9 is a diagram sho wing a startup screen in the first preferred embodiment of the present invention;

FIG. 10 is a diagram showing a contrast adjustment screen fo r recipe creation in the first preferred embodiment of the present

invention;

FIG. 11 is a diagram showing a trial inspe ction initial screen for recipe creation in the first preferred embodiment of the present invention;

FIG. 12 is a plan view of a wafer, showing a scanning sequence in the first preferred embodiment of the present invention;

FIG. 13 is a diagram sh owing a trial inspecti on defect check screen for recipe creation in the first preferred embodiment of the present invention;

FIG. 14 is a diagram showing a mask regi on setting screen for recipe creation in the first preferred embodiment of the present invention;

FIG. 15 is a diagram showing an inspectio n defect check screen in the first preferred embodiment of the present invention;

FIG. 16 is a front view showing a configurati on of an electron-beam pattern inspection apparatus in a second preferred embodimen t of the present invention;

FIG. 17 is a diagram showing an image proc essing region setting screen for recipe creation in the second preferred embodiment of the present invention;

FIG. 18 is a front view showing a configurati on of an electron-beam pattern inspection apparatus in a third preferred embodiment of the present invention;

FIG. 19 is a diagram showing a defect ch eck screen for recipe

creation in the thir d preferred embodime nt of the present in vention; and

FIG. 20 is a diagram showing an image proce ssing feature quantit y data setup screen for recipe creation in the third preferred embodiment of the present invention.·

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will now be describ ed in detail by way of example with reference to the accompanying drawings.

Embodiment 1:

The following describes a first preferre d embodiment of the present invention. Referring to FIG. 8, th ere is shown a configu ration of an electron-beam pattern inspection apparatus in the first pr eferred embodiment of the present invention. The electron-beam pattern inspection apparatus comprises an electron optical system 106 including; an electron source 1 for emitting an elec tron beam 2, an elect ron gun 102 in which the elec tron beam 2 from the electron source 1 is extracted and accelerated by an electrode to produce a virtual electron source 101 at a predetermined point through an electrostatic or magnetic field superimposing lens, a condenser lens 103 for converging the electron beam 2 from the virtual electron source 101 at a predetermined convergence point, a blanking plate 104 which is equ ipped in the vicinit y of the convergence point of the electron beam 2 for turning on/off the electron

beam 2, a deflector 105 for deflecting the electron beam 2 in the X and Y directions, and an objective lens 4 for converging the electron beam 2 onto an object substrate 5. Further, the electron-beam pattern inspection apparatus comprises a specimen chamber 107 in which the object substrate 5 (wafer 31) is held in vacuum, a stage 6 where the wafer 31 is mounted and a retarding voltage 108 is applied for enabling detection of an image at an arbit rary position, a detec tor 8 for detecting se condary electrons 7 or the like produced from the object substrate 5 to output a detected analog signal, an A/D converter 9 for converting the detected analog signal into a digital image, a memory 109 for storing digital image data, an image processor circuit 10 in which the converted digital image is compared with a reference digit al image stored in th e memory 109 and a difference found in comparison is indicated as a candidate defect 40, a candidate defect memory part 41 for storing feature qu antity data of each candidate defect 40 such as coordinate data, projection length data and shape data, a general cont rol part 110 in which entire apparatus control is conducted, feature quantity data of each pattern defect 11 is received from the candidate defect memory part 41, a mask region 42 (shown in FI G. 5) is set as region data, and a candidate defect located in the mask region 42 is flagged as a masked defect 43 (shown in FIG. 5) (control li nes from the general control part 110 are no t shown in FIG. 8), and an ope ration display 45 on which data of pattern defects 11 is displayed, an image of a selected pattern defect 11 is displayed, and the mask region 42 is displayed or edited. Still furt her, the

electron-beam pattern inspection apparatus comprises a keyboard 120, a mouse 121 and a knob 122 (not shown) for operation and control, a Z sensor 113 for measuring the height level of each wafer 31 to maintain a focal point of a detected digital image through control of a current applied to the objective lens by adding an offset 112, a loader 116 (not shown) for loading the wafer 31 from its cassette 114 to the specimen chamber 107 and unloading the wafer 31 from the specimen chamber 107 to the cassette 114, an orientation flat detector 117 (not shown) for positioning the wafer 31 according to the circumferential shape of the wafer 31, an optical microscope 118 for allowing observation of a pattern on the wafer 31, and a standard specimen 119 which is set on the stage 6.

Operations in the first preferred embodiment are described below, which include a conditioning operation in which a mask region 42 is set up and an inspection operation in which any candidate defect 40 detected in other than the mask region 42 is examined as a pattern defect.

In the conditioning operation, a user opens a startup screen shown in FIG. 9 on the operation display 45. On a slot selection part 130 of the startup screen, the user selects a code number of a slot where the wafer 31 to be inspected is contained. Then, on a recipe selection part 131, the user specifies a product type of the wafer 31 and a process step thereof, and the user presses a recipe creation start button 132 for starting the conditioning operation. The conditioning operation includes; contrast setting for the electron optical system 106, pattern

layout setting for the wafer 31, pattern positioning alignment for the wafer 31, calibration in which a signal level of the wafer 31 is checked at a position where the signal level is indicated accurately, inspection condition setting, mask region setting, and setup condition check in trial inspection. Described below are the contrast setting, mask region setting, and trial inspection, which form essential parts of the present invention.

The general control part 110 provides operational instructions to each part in the following manner.

First, the general control part 110 issues an operational instruction to the loader 116 (not shown) so that the loader 116 takes the wafer 31 out of the cassette 114. Then, through the use of the orientation flat detector 117 (not shown), the circumferential shape of the wafer 31 is checked, and the wafer 31 is positioned according to the result of this check. The wafer 31 is then mounted on the stage 6, and the specimen chamber 107 is evacuated. Simultaneously, the electron optical system 106 and the retarding voltage 108 are conditioned. A voltage is applied to the blanking plate 104 to turn off the electron beam 2. The stage 6 is moved so that the standard specimen 119 can be imaged, and an output of the Z sensor 113 is made effective. While a focal point of the electron beam 2 from the electron optical system 106 is maintained at a position corresponding to "a value detected by the Z sensor 113 + an offset 112", raster scanning is performed by the deflector 105. In synchronization with this raster scanning, the voltage applied

to the blanking plate 104 is turned off so that the wafer 31 is irradiated with the electron beam 2 as required. Backscattered electrons or secondary electrons produced from the wafer 31 are detected by the detector 8, which then outputs a detected analog signa l. Through the A/D converter 9, the detected anal og signal is convert ed into a digital image. By changing the offset 112, a plurality of digital images are detected, and in the general con trol part 110, an opti mum offset 111 for max imizing the sum of image diffe rential values is det ermined. The optimum offset 111 thus determined is set up as the current offset value.

After the optimum off set 111 is establishe d, the output of the Z sensor 113 is made ineffective and a screen transition is made to a contrast adjustment screen shown in FIG. 10. The contrast adj ustment screen comprises: a map display part 55 having a map display area, a button for controlli ng display of the en tire wafer or die ma p, and a mouse operation command button 140 for controlling position movement or item selection by the use of the mouse 121 (not shown); an image display part 56 having an image display area and an image changeover button 141 for setting an image ma gnification, selecting an optical microgra p h image attained through the optical microscope 118 or a SEM image attained through the electron optical system 106, and speci fying a kind of image; a recipe creation item selection button 142; a recipe creation end button 133; and a recipe save but ton 134. On the cont rast adjustment scre en, the user sets the mouse operation command bu tton 140 to a moveme nt mode, and performs movement on the map by clicking the mouse 121 to view an

image at the current position on the image display part. Then, the user assigns an adjustmen t item of the electr on optical system 10 6 to the knob 122, and adjust s each part of the electron optical syste m 106 to attain proper contrast.

The recipe creation end button 133 is used for terminating recip e creation, the recipe save button 134 is used for saving recipe condition data, and the recipe cr eation item selection button 142 is used for setting another condition and issuing an instruction for screen transition. These buttons are available on all the screens. To open a trial ins pection initial screen shown in FIG. 11, the user sets the recipe creation item selection button 142 to a trial inspection item.

The trial inspection initial screen compri ses a map display part 55, a recipe creation end button 133, a rec ipe save button 134, a recipe creation item selection button 142, an inspection start button 143, and an inspection end but ton 144. The user set s the mouse operation command button 140 to a select ion mode. Then, by clicking a die on the map display part 55, the user can select/deselect the di e for trial inspection . Each die can thus be selec ted for trial inspect ion. After selecting any die for trail inspection, the user presses the inspection start button 143 to start trial inspec tion. When trial ins pection is started, the stage 6 is driven for movem ent to a scanning sta rt position of the re gion to be inspected on the wafer 31 mounted the reon. A pre-measured offset value inherent in the wafer 31 is added to the offset 112, and the Z sensor 113 is made ef fective. Then, alon g the scanning line 33 shown

in FIG. 3, the stage 6 is scanned in the Y direction. In synchronization with this stage scanning, the deflector 105 is scanned in the X direction. During a period of effective scanning, a voltage to the blanking plate 104 is turned off to let the electron beam 2 fall on the wafer 31 for scanning the surface thereof. Backscattered electrons or secondary electrons produced from the wafer 31 are detected by the detector 8, and through the A/D converter 9, a digital image of the stripe region 34 is attained. The digital image thus attained is stored into the memory 109. After completion of the scanning operation of the stage 6, the Z sensor 113 is made ineffective. The entire region of interest can be inspected by repeating stage scanning. In cases where the entire surface of the wafer 31 is inspected, a scanning sequence shown in FIG. 12 is taken.

When the detection position A 35 is taken in the image processor circuit 10, an image attained at the detection position A 35 is compared with an image attained at the detection position B 36, which has been stored in the memory 109. If any difference is found in comparison, the difference is extracted as a candidate defect 40 to prepare a list of pattern defects 11. The list of pattern defects 11 thus prepared is sent to the general control part 110. In the general control part 110, feature quantity data of each pattern defect 11 is taken out of the candidate defect memory part 41. A pattern defect 11 located in the mask region 42, which has been registered in a recipe, is flagged as a masked defect 43 (feature quantity data thereof is flagged). After

completion of inspect ion of the entire regi on of interest, the us er opens a trial inspection defect check screen shown in FIG. 13.

The trial inspection defect check screen com prises a defect displa y editing part 150 for displaying feature quantity data of defects and editing classification thereof, a map display part 55 in which a current position indicator 59 indicating the cur rent position and cl ass code symbols of pattern defects 11 are displa yed on a layout of the wafer 31, an image dis play part 56 in which an imag e taken at the current position is displayed, a display changeover button 151 for turning on/off masked defects 43, and othe r buttons which have already been described. The user sets the mouse operation command butt on 140 to the selecti on mode, and then clicks any pattern defect 11 indicated on the map display part 55. Thus, an image of the pattern defect 11 is presented on th e image display part 56, and feature quantity data thereof is presente d on the defect display editi ng part 150. On the defect display editi ng part 150, the pattern defect 11 is subjected to classification according to the image and feature quantity data thereof, i.e., a class code is assigned to the feature quant ity data of the patte rn defect 11. At this step, if it is desir ed to treat the pattern def ect 11 as a masked de fect, a particular class code is assigned thereto. Thus, it can be identified as a masked defect on the map display part 55. After completion of the defect classification , the user makes a trans ition to a mask region setting screen shown in FIG. 14 by using the recipe cr eation item selection button, or the user returns to the trial inspectio n initial screen by pressing

the inspection end button.

The mask region setti ng screen comprises a map display part 55 in which a current position indicator 59 indicating the current position, class code symbols of pattern defects 11, and a mask region 42 are displayed on a layout of the wa fer 31, an image disp lay part 56 in which an image taken at the current position is displayed, a display changeover button 151 for turning on/o ff masked defects 43, a new region button 160 for creating a new mask region, a completion button 161 for indicat ing the end of creation of a new mask region, and oth er buttons which have already described. Note tha t the map display par t 55 presents the ent ire die region. The current position indicator 59 and pattern defec ts 11 in the entire die regi on are indicated in representation of on-die coordinates.

The user sets the mouse operation command button 140 to the movement mode, and then clicks in the vicinity of a class code of any defect to be masked for making movement thereto. Thus, an image of the defect to be masked is presented on the image display part 56. If the user judges that a mask region should be form ed, the user presses the new creation button 160 to select a region creation mode. In th is mode, the user defines a ma sk region by clicking at the upper left co rner and the lower right corner thereof on the image display part. The mask region thus defined (mask re gion 42) is indicated on the map display part 55. After creating the mask region as mentio ned above, the user can turn on/off masked defects 43 by pressing the display changeover button 151

to confirm the location of the defect to be masked. When the mask region 42 is set up as required, the user presses the recipe save button 134 for saving data of the mask region 42 in a recipe.

After saving the data of the mask region 42, the user presse s the completion button 161 to return to the trial inspection defect check screen. Further, on the trial inspection defect check screen, the user presses the inspectio n end button 144 to re turn to the trial ins pection initial screen. Then , it is also allowed for the user to select another die for trial insp ection. For confirming and terminating the above-mentioned recipe creation session, the user presses th e recipe creation end button 133. Upon completio n of the recipe creat ion, the wafer 31 is unloaded back to the cassette 114.

The following descri bes the inspection operation in which an y candidate defect detected in other than the mask region is exa mined as a pattern defect. In the inspection operat ion, the user opens the startup screen shown in FIG. 9 on the operation display 45. On the slot se lection part 130 of the start up screen, the user selects a code number of a slot where the wafer 31 to be inspected is cont ained. Then, on the recipe selection part 131, the user specifies a product type of the wafer 31 and a process step thereof, and the user presses an inspecti on start button 330 for starti ng the inspection ope ration. After wafer loading, alignment and calibration are made, inspection processing is carried out. Then, defect ch eck and defect data ou tput are performed, and wafer unloading is made at the end of inspecti on. Described below are the

inspection processing and defect check, which form essential parts of the present invention.

When the user presses the inspection start button 330 to indicat e the start of inspecti on, the stage 6 is dri ven for movement to a scanning start position of the region to be inspe cted on the wafer 31 mounted thereon. A pre-measu red offset value inhe rent in the wafer 31 is added to the offset 112, an d the Z sensor 113 is made effective. Then, along the scanning line 33 shown in FIG. 3, the stage 6 is scanned in the Y direction. In synchronization . of this s tage scanning, the deflector 105 is scanned in the X direction. During a period of effective sc anning, a voltage to the blanking plate 104 is turned off to let the electron beam 2 fall on the wafer 31 for scanning the surface thereof. Backscattered electrons or secondary elec trons produced from the wafer 31 are detected by the detector 8, and through the A/D converter 9, a digital image of the stripe region 34 is attained. The digita l image thus attained is sto red into the memory 109. After completio n of the scanning operation of the stage 6, the Z se nsor 113 is made ineffective. The entire region of in terest can be inspecte d by repeating stage sc anning. In cases where the entire surface of the wafer 31 is inspected, the scanning sequence shown in FIG. 12 is taken.

When the detection po sition A 35 is taken in the image processor circuit 10, an image attained at the detection position A 35 is compared with an image attain ed at the detection position B 36, which has been stored in the memory 109. If any differ ence is found in com parison,

the difference is ext racted as a candidate defect 40 to prepare a list of pattern defects 11. The list of patt ern defects 11 thus prepared is sent to the genera l control part 110. In the general contr ol part 110, feature quantit y data of each patte rn defect 11 is take n out of the candidate defect memory part 41. A pattern defect 11 lo cated in the mask region 42, which has been regist ered in a recipe, is flagged as a masked defect 43 (feature quantity dat a thereof is flagged) . After completion of inspection of the entire region of interest, an inspection defect check screen shown in FIG. 15 is opened.

The inspection defec t check screen compr ises a defect displa y editing part 150 for displaying feature quantity data of defects and editing classification thereof, a map display part 55 in which a current position indicator 59 indicating the cur rent position and cl ass code symbols of pattern defects 11 are displa yed on a layout of the wafer 31, an image dis play part 56 in which an imag e taken at the current position is displayed, a display changeover button 151 for turning on/off masked defects 43, and an in spection end button 144 for indicating the end of inspection.

The user sets the mo use operation comman d button 140 to the selection mode, and then clicks any patter n defect 11 indicated on the map display part 55. Thus, an image of the pattern defect 11 is presented on the image display pa rt 56, and feature quan tity data thereof is pr esented on the defect display editing part 150. On the defect display editing part 150, the pattern defect 11 is subjected to classification according

to the image and feature quantity data thereof, i.e., a class code is assigned to the feature quantity data of the pattern defect 11. Using the display changeover button 151, the user can turn on/off masked defects 43 to check for any pattern defect in the mask region 41. To terminate the inspection defect check session mentioned above, the user presses the inspection end button 144. Each classified pattern defect 11 and feature quantity data thereof are stored into memory means (not shown) in the general control part 110, and also delivered to external memory means (not shown) through a communication line (not shown) or to other inspection/observation means (not shown). Then, control is returned to the initial screen.

According to one aspect of the first preferred embodiment, the entire surface of each wafer can be inspected using a SEM image thereof without regard to pattern defects in the mask region 42, i.e., true pattern defects 57 only can be indicated to the user for easy identification thereof.

Further, according to another aspect of the first preferred embodiment, it is also allowed to display masked defects in the mask region 42. Therefore, in cases where rough patterning is made to form a redundant power wiring layer, a degree of roughness in patterning can be examined by turning on/off the masked defects.

Still further, according to another aspect of the first preferred embodiment, the mask region 42 can be set so as to mask false defects which have been identified under actual inspection conditions. It is

therefore possible for the user to define proper masking.

Furthermore, according to another aspect of the first preferre d embodiment, a different mask region 42 can be created additionally. Therefore, in cases where masking has been defined using an object containing a small degree of random vari ation, the user can set up a new mask region addit ionally for providing proper masking as re quired.

In a first modified fo rm of the first prefer red embodiment, mask region management may be implemented in a par t of image processing function hardware instead of using the general co ntrol part that is a computer system. In this modified arrangement, the essentially same functionality is pro vided. Since the num ber of detectable def ects is limited in terms of output capacity, this limitation can be rem oved by using image processing function hardware for mask region man agement.

In a second modified fo rm of the first preferr ed embodiment, plural kinds of mask regions may be set up while only one kind of mask region has been treated in the forgoing descr iption. In this modified arrangement, false defects due to plural kinds of causes can be classified for defect data mana gement. By turning on/off indications of false defects according to each kind of cause, the user can check con ditions thereof. Thus, it is possible for the user to preclude only minimum false defects for carrying out proper inspection.

In a third modified form of the first pr eferred embodiment, a mask region on the mask region setting screen may be automatically defined as a rectangular regi on having a size appr oximately two times as large

as the projection length of any false defect not to be detec ted. By merging neighboring mask regions, a mask region is determined using data of pattern defects classified without intervention of the user. In this modified arrangement, a mask region can be generated precisely through automatic operation. For example, maski ng at hundreds points can be provided automatically so as to allow easy identification. As a further modified form of this modification, there may be provided such an arrangement that an au tomatically determined mask region can be re defined or edited.

In a fourth modified form of the first pre ferred embodiment, a mask region may be de termined using design data in inspection of rough patterning for power wiring, ion implant ation, or the like. In this modified arrangement, the user can set up a mask region for ea ch kind of false defect while saving the time of input.

In a fifth modified for m of the first preferre d embodiment, pattern defects are indicated on layout information at a networked CAD display terminal instead of being indicated on layout information stored in the inspection apparatus. In this modified arrangement, possible defects on each layer in roug h patterning and fine patterning can be id entified with ease.

Embodiment 2:

The following descri bes a second preferr ed embodiment of the present invention. Referring to FIG. 16, there is shown a configuration

of an electron-beam pattern inspection apparatus in the second preferred embodiment of the present invention. The electron-beam pattern inspection apparatus comprises an electron optical system 106 including; an electron source 1 for emitting an electron beam 2, an electron gun 102 in which the electron beam 2 from the electron source 1 is extracted and accelerated by an electrode to produce a virtual electron source 101 at a predetermined point through an electrostatic or magnetic field superimposing lens, a condenser lens 103 for converging the electron beam 2 from the virtual electron source 101 at a predetermined convergence point, a blanking plate 104 which is equipped in the vicinit y of the convergence point of the electron beam 2 for turning on/off the electron beam 2, a deflector 105 for deflecting the electron beam 2 in the X and Y directions, and an objective lens 4 for converging the electron beam 2 onto an object substrate 5. Further, the electron-beam pattern inspection apparatus comprises a specimen chamber 107 in which the object substrate 5 (wafer 31) is held in vacuum, a stage 6 where the wafer 31 is mounted and a retarding voltage 108 is applied for enabling detection of an image at an arbit rary position, a detec tor 8 for detecting se condary electrons 7 or the like produced from the object substrate 5 to output a detected analog signal, an A/D converter 9 for converting the detected analog signal into a digital image, a me mory 109 for storing digital image data, an image processor circuit 202 in which the converted digital image is compared with a reference digit al image stored in the memory 109 and a difference found in comparison by changing an image processing

condition 201 for each image processing regi on 200 is detected as a pattern defect 11, a general control part 110 in which feature quant ity data 203 of each pattern defect 11 such as coordinate data, projection length data and shape data is handled (control li nes from the general control part 110 are not show n in FIG. 16), and an operation display 45 on which data of pattern defects 11 is displayed, an image of a selected pattern defect 11 is displayed , and each image proce ssing region 200 is di splayed or edited. Still further, the electron-beam pattern inspection apparatus comprises a keyboard 120, a mouse 121 and a knob 122 (not shown) for operation and control, a Z sensor 113 for measuring the height level of each wafer 31 to maintain a focal point of a detected digita l image through control of a current applied to the objective lens by adding an offset 112, a loader 116 (not shown) for loading the wafer 31 from its cassette 114 to the specimen chamber 107 and unloading the wafer 31 from the specimen chamber 107 to the cassette 114, an ori entation flat detector 117 (not shown) for positioning the wafer 31 according to the circumferentia l shape of the wafer 31, an optical microsc ope 118 for allowing observa tion of a pattern on the wafer 31, and a standard specimen 119 which is set on the stage 6.

Operations in the second preferred embodiment are described below, which include a conditioning operation in which an image processing region 200 and an image pro cessing condition 201 thereof are set up and an inspection operation in which pattern defects 11 are detected.

In the conditioning operation, the user opens the startup screen shown

in FIG. 9 on the operation display 45. On a slot selection part 130 of the startup screen, the user selects a code number of a slot where the wafer 31 to be inspected is contained. Then, on a recipe selection part 131, the user specifies a product type of the wafer 31 and a process step thereof, and the user presses a recipe creation start button 132 for starting the conditioning operation. The conditioning operation includes; contrast setting for the electron optical system 106, pattern layout setting for the wafer 31, pattern positioning alignment for the wafer 31, calibration in which a signal level of the wafer 31 is checked at a position where the signal level is indicated accurately, inspection condition setting, image processing region setting 204 for specifying an image processing region 200 and an image processing condition 201 thereof, and setup condition check in trial inspection. Described below are the contrast setting, image processing region setting, and trial inspection, which form essential parts of the present invention.

The general control part 110 provides operational instructions to each part in the following manner. First, the general control part 110 issues an operational instruction to the loader 116 (not shown) so that the loader 116 takes the wafer 31 out of the cassette 114. Then, through the use of the orientation flat detector 117 (not shown), the circumferential shape of the wafer 31 is checked, and the wafer 31 is positioned according to the result of this check. The wafer 31 is then mounted on the stage 6, and the specimen chamber 107 is evacuated. Simultaneously, the electron optical system 106 and the retarding voltage

108 are conditioned. A voltage is applied to the blanking plate 104 to turn off the electron beam 2. The stage 6 is moved so that the standard specimen 119 can be imaged, and an output of the Z sensor 113 is made effective. While a focal point of the electron beam 2 is maintained at a position corresponding to "a value detected by the Z sensor 113 + an offset 112", raster scanning is performed by the deflector 105. In synchronization with this raster scanning, the voltage applied to the blanking plate 104 is turned off so that the wafer 31 is irradiated with the electron beam 2 as required. Backscattered electrons or secondary electrons produced from the wafer 31 are detected by the detector 8, which then outputs a detected analog signal. Through the A/D converter 9, the detected analog signal is converted into a digital image. By changing the offset 112, a plurality of digital images are detected, and in the general control part 110, an optimum offset 111 for maximizing the sum of image differential values is determined. The optimum offset 111 thus determined is set up as the current offset value.

After the optimum offset 111 is established, the output of the Z sensor 113 is made ineffective and a screen transition is made to a contrast adjustment screen such as shown in FIG. 10. The contrast adjustment screen comprises: a map display part 55 having a map display area, a button for controlling display of the entire wafer or die map, and a mouse operation command button 140 for controlling position movement or item selection by the use of the mouse 121 (not shown); an image display part 56 having an image display area and an image changeover button 141

for setting an image magnification, selecting an optical micrograp h image attained through the optical microscope 118 or a SEM image attained through the electron optical system 106, and speci fying a kind of image; a recipe creation item selection button 142; a recipe creation end button 133; and a recipe save but ton 134. On the cont rast adjustment scre en, the user sets the mouse operation command bu tton 140 to a moveme nt mode, and performs movement on the map by clicking the mouse 121 to view an image at the current position on the image display part. Then, the user assigns an adjustmen t item of the electr on optical system 10 6 to the knob 122, and adjust s each part of the el ectron optical syste m 106 to attain proper contrast.

The recipe creation end button 133 is used for terminating recip e creation, the recipe save button 134 is used for saving recipe condition data, and the recipe cr eation item selection button 142 is used for setting another condition and issuing an instruction for screen transition. These buttons are available on all the screens. To open a trial ins pection initial screen such as shown in FIG. 11, the user sets the recipe creation item selection button 142 to a trial inspection item.

The trial inspection initial screen compri ses a map display part 55, a recipe creation end button 133, a rec ipe save button 134, a recipe creation item selection button 142, an inspection start button 143, and an inspection end but ton 144. The user set s the mouse operation command button 140 to a select ion mode. Then, by clicking a die on the map display part 55, the user can select/deselect the di e for trial inspection . Each

die can thus be selec ted for trial inspect ion. After selecting any die

for trail inspection, the user presses the inspection start button 143

to start trial inspec tion. When trial ins pection is started, the stage

6 is driven for movem ent to a scanning sta rt position of the re gion to

be inspected on the wafer 31 mounted thereon.

A pre-measured offse t value inherent in the wafer 31 is adde d

to the offset 112, an d the Z sensor 113 is made effective. Then, along

the scanning line 33 shown in FIG. 3, the stage 6 is scanned in the Y

direction. In synchronization with this s tage scanning, the de flector

105 is scanned in the X direction. During a period of effective sc anning,

a voltage to the blanking plate 104 is turned off to let the electron

beam 2 fall on the wafer 31 for scanning the surface thereof.

Backscattered electrons or secondary elec trons produced from the wafer

31 are detected by the detector 8, and through the A/D converter 9, a

digital image of the stripe region 34 is attained. The digita l image

thus attained is sto red into the memory 109. After completio n of the

scanning operation of the stage 6, the Z se nsor 113 is made ineffective.

The entire region of in terest can be inspecte d by repeating stage sc anning.

In cases where the ent ire surface of the waf er 31 is inspected, a scanning

sequence shown in FIG. 12 is taken.

When the detection po sition A 35 is taken in the image processor

circuit 202, an image attained at the detec tion position A 35 is compared

with an image attain ed at the detection position B 36, which has been

stored in the memory 109. If any differ ence is found in com parison,

the difference is extracted as a pattern defect 11 to prepar e a list of pattern defects 11. The list of patt ern defects 11 thus prepared is sent to the general control part 110. After completion of ins pection of the entire region of interest, the user opens a trial inspectio n defect check screen such as shown in FIG. 13.

The trial inspection defect check screen comprises a defect display editing part 150 for displaying feature quantity data of defects and editing classifi cation thereof, a ma p display part 55 in which a current position indicator 59 indicating the current position and class code symbols of patte rn defects 11 are disp layed on a layout of the wafer 31, an image dis play part 56 in which an imag e taken at the current position is displayed, a display changeover button 151 for turning on/off masked defects 43, and other buttons which have already been described.

The user sets the mo use operation comman d button 140 to the selection mode, and then clicks any patter n defect 11 indicated on the map display part 55. Thus, an image of the pattern defect 11 is presented on the image display pa rt 56, and feature quan tity data thereof is pr esented on the defect display editing part 150. On the defect display editing part 150, the pattern defect 11 is subjected to classification according to the image and feat ure quantity data th ereof, i.e., a class code is assigned to the featu re quantity data of th e pattern defect 11. At this step, if it is desired to treat the pattern defect 11 as a masked defect, a particular class co de is assigned theret o. Thus, it can be id entified as a masked defect on the map display part 55. After completion of the

defect classification, the user makes a tran sition to an image processing

region setting screen 205 shown in FIG. 17 by using the recipe creation

item selection button, or the user returns to the trial inspection initial

screen by pressing the inspection end button.

The image processing region setting scree n 205 comprises a map

display part 55 in wh ich a current positio n indicator 59 indica ting the

current position, class code symbols of pattern defects 11, and an image

processing region 200 are displayed on a la yout of the wafer 31, an image

display part 56 in which an image taken at the current position is displayed,

a defect redisplay button 207 for defect indication based on feature

quantity image data 203 of each pattern de fect 11, a new region button

160 for creating a new region, a completi on button 161 for ind icating

the end of creation of a new region, and oth er buttons which have already

described. Note tha t the map display par t 55 presents the ent ire die

region. The current position indicator 59 and pattern defec ts 11 in

the entire die regi on are indicated in representation of on-die

coordinates. The us er sets the mouse ope ration command button 140 to

the movement mode, and then clicks in the vicinity of a class code of

any defect corresponding to the image processing condition 201 to be

changed for making movement thereto. Th us, an image of the defect of

interest is presented on the image display part 56.

If the user judges tha t the image processin g condition 201 shoul d

be changed, the user presses the new cre ation button 160 to select a

region creation mode. In this mode, the use r defines a region by clicking

at the upper left cor ner and the lower rig ht corner thereof on the image display part, and the user provides a correspondence between an image processing condition number 206 of the regio n and a class code. Re ference is made to the feature quantity image data 203 of a pattern defect 11 having the class code which corresponds to the image processing condition number 206, and the image processing con dition 201 is set up for the image processing condition number 206 so th at all-defects detection will not be made by the im age processor circui t or software in the general control part (compu ter). As required, the user adjusts the image processing condition 201 manually. Using a special conditio n on/off button 208, the user specifies whether or not the image processing condition 201 is to be applied at the ti me of inspection. On the map display part 55, the defined region is ind icated as an image pr ocessing region 200 together with the image processing condition number 206. After creating the image processing region 200 as mentioned above, the user presses the defect redisplay button 207 to confirm that each pattern defect 11 belonging to the image processing region 200 is not indicated. When the image proce ssing region 200 is set up as required, the user presses the recipe s ave button 134. Thu s, data regarding th e image processing region 200, the image processing condition number 206 corresponding thereto, and the image proc essing condition 201 for each image processing number are saved in a recipe.

After saving the above data, the user presses the completion button 161 to return to the trial inspection de fect check screen. Further,

on the trial inspection defect check screen, the user presses the inspection end button 144 to return to the tri al inspection initial screen. Then, it is also allowed for the user to select another die for trial inspection. For confirming and terminatin g the above-mentioned recipe creation session, the user presses the recipe creation end button 133. Upon completion of the recipe creation, the wafer 31 is unloa ded back to the cassette 114.

The following descr ibes the inspection operation. In the inspection operation, the user opens the startup screen shown in FIG. 9 on the operation display 45. On the sl ot selection part 13 0 of the startup screen, the user selects a code number of a slot where the wafer 31 to be inspected is contained. Then, on the recipe select ion part 131, the user specifies a product type of the wafer 31 and a process step thereof, and th e user presses an ins pection start button 330 for starting the inspection operation. After wafer loading, alignment and calibration are made, inspection processing is carried out. Then , defect check and defect data output are performed , and wafer unloading is made at the end of inspection. Described below are the inspection processing and defect check, which form essential parts of the present invention.

When the user presses the inspection start button 330 to indicat e the start of inspecti on, the stage 6 is dri ven for movement to a scanning start position of th e region to be inspe cted on the wafer 31 mounted thereon. A pre-measu red offset value inhe rent in the wafer 31 is added to the offset 112, an d the Z sensor 113 is made effective. Then, along

the scanning line 33 shown in FIG. 3, the stage 6 is scanned in the Y direction. In synchronization of this stage scanning, the deflector 105 is scanned in the X direction. During a period of effective scanning, a voltage to the blanking plate 104 is turned off to let the electron beam 2 fall on the wafer 31 for scanning the surface thereof. Backscattered electrons or secondary electrons produced from the wafer 31 are detected by the detector 8, and through the A/D converter 9, a digital image of the stripe region 34 is attained. The digita l image thus attained is sto red into the memory 109. After completio n of the scanning operation of the stage 6, the Z sensor 113 is made ineffective. The entire region of in terest can be inspecte d by repeating stage sc anning. In cases where the entire surface of the wafer 31 is inspected, the scanning sequence shown in FIG. 12 is taken.

When the detection po sition A 35 is taken in the image processor circuit 202, an image attained at the detec tion position A 35 is compared with an image attain ed at the detection position B 36, which has been stored in the memory 109. If any differ ence is found in com parison, the difference is ex tracted as a pattern defect 11 to prepar e a list of pattern defects 11. The list of patt ern defects 11 thus prepared is sent to the general control part 110. Af ter completion of ins pection of the entire region of interest, an inspection defect check screen such as shown in FIG. 15 is opened.

The inspection defec t check screen compr ises a defect displa y editing part 150 for displaying feature quantity data of defects and

editing classification thereof, a map display part 55 in which a current position indicator 59 indicating the cur rent position and cl ass code symbols of pattern defects 11 are displa yed on a layout of the wafer 31, an image dis play part 56 in which an imag e taken at the current position is displayed, a display changeover button 151 for turning on/off masked defects 43, and an in spection end button 144 for indicating the end of inspection. The user sets the mouse ope ration command butto n 140 to the selection mode, and then clicks any pa ttern defect 11 indic ated on the map display part 55. Thus, an image of the pattern defect 11 is presented on the image display part 56, and feature quantity data thereof is presented on the defect display editing part 150. On the defect display editing part 150, the pattern defect 11 is subjected to classification according to the imag e and feature quantit y data thereof, i.e., a class code is assigned to the feature quantity data of the pattern defect 11.

A display changeover button 209 is provide d for turning on/off the display for the image processing condition 201 in the image processing region 200. With thi s button, the user can perform a display cha ngeover according to whether or not the image proces sing condition 201 is applied to each pattern defe ct 11 in the image pr ocessing region 200. If, by using the special condition on/off button 208, the user has specified that the image proce ssing condition 201 is to be applied at the time of inspection, a display changeover with the image display changeover button 209 is not available since the image processing condition 201 is already applied. To terminate the insp ection defect check session

mentioned above, the user presses the insp ection end button 144 . Eac h classified pattern defect 11 and feature quantity data thereof are stored into memory means (not shown) in the general control part 110, and also delivered to external memory means (not sh own) through a commun ication line (not shown) or to other inspection/ob servation means (not shown). Then, control is returned to the initial screen.

According to one aspe ct of the second pref erred embodiment, the entire surface of each wafer can be inspected using a SEM image thereof without regard to pattern defects in the image processing region 200, i.e., true pattern de fects 57 only can be indicated to the user for easy identification thereof.

Further, according to another aspect of the second preferred embodiment, it is also allowed to display de fects in the image pro cessing region 200. Therefor e, in cases where rou gh patterning is made to form a redundant power wir ing layer, a degree of roughness in patter ning can be examined by means of display changeover.

Still further, according to another aspect of the second preferred embodiment, an image processing condition can be set so that false defects identified under actual inspection conditions will not be detect ed. It is therefore possible for the user to speci fy a threshold proper ly just as required.

Furthermore, according to another aspect of the second preferre d embodiment, a differ ent image processing region 200 can be created additionally. There fore, in cases where the image processing condition

201 has been defined using an object containing a small degree of random variation, the user can set up a new image processing region additionally to provide proper conditioning for image processing as required.

Moreover, according to another aspect of the second preferre d embodiment, the image processing condition 201 is adjustable without completely deleting data of pattern defects 11 in the image pro cessing region 200. Therefor e, the user can adjust the image processing condition 201 so that false def ect detection will be prevented as require d while possible defects remain inspectable.

Still further, according to another aspect of the second preferred embodiment, in cases where, by using the special condition on/off button 208, the user has spe cified that the image processing condition 201 is not to be applied at the time of inspectio n, it is allowed to alter the image processing region 200 and the image processing condition 201. Therefore, even if it becomes necessary to provide a different image processing condition due to variation in a fabrication process, the user has only to adjust the image processing condition 201. Thus, inspection can be carried out using feature quantity data 203 acquired already.

Embodiment 3:

The following describes a third preferre d embodiment of the present invention.

Referring to FIG. 18, there is shown a configuration of an electron-beam pattern inspection appara tus in the third pr eferred

embodiment of the present invention. The electron-beam pattern inspection apparatus comprises an electron optical system 106 including; an electron source 1 for emitting an electron beam 2, an electron gun 102 in which the electron beam 2 from the electron source 1 is extracted and accelerated by an electrode to produce a virtual electron source 101 at a predetermined point through an electrostatic or magnetic field superimposing lens, a condenser lens 103 for converging the electron beam 2 from the virtual electron source 101 at a predetermined convergence point, a blanking plate 104 which is equipped in the vicinity of the convergence point of the electron beam 2 for turning on/off the electron beam 2, a deflector 105 for deflecting the electron beam 2 in the X and Y directions, and an objective lens 4 for converging the electron beam 2 onto an object substrate 5. Further, the electron-beam pattern inspection apparatus comprises a specimen chamber 107 in which the object substrate 5 (wafer 31) is held in vacuum, a stage 6 where the wafer 31 is mounted and a retarding voltage 108 is applied for enabling detection of an image at an arbitrary position, a detector 8 for detecting secondary electrons 7 or the like produced from the object substrate 5 to output a detected analog signal, an A/D converter 9 for converting the detected analog signal into a digital image, a memory 109 for storing digital image data, an image processor circuit 10 in which the converted digital image is compared with a reference digital image stored in the memory 109 and a difference found in comparison is indicated as a candidate defect 40, a candidate defect memory part 41 for storing feature quantity

data 203 of each candidate defect 40 such as coordinate data, projection

length data and shape data, a feature quan tity check part 251 in which

feature quantity data 203 of each candida te defect 40 is recei ved from

the candidate defect memory part 41 and it is checked whether the ca ndidate

defect 40 meets prespecified feature quantity data 250, a detail image

processing part 252 in which, under an image processing condition 201

specified for each feature quantity data , a judgment for det ermining

each pattern defect 11 is formed on the candidate defect 40 that has

proved to meet the prespecified feature quantity data 250 by the feature

quantity data check part 251, a general co ntrol part 110 in whi ch data

of each pattern defec t 11 is received from the detail image pro cessing

part 252 (control lines from the general control part 110 are not shown

in FIG. 18), and an op eration display 45 on which data of pattern defects

11 is displayed, an image of a selected pattern defect 11 is displayed,

and the image processi ng region 200 is displa yed or edited. Still further,

the electron-beam pattern inspection apparatus comprises a keyboard 120,

a mouse 121 and a kno b 122 (not sho wn) for operation and cont rol, a Z

sensor 113 for measur ing the height level of each wafer 31 to maintain

a focal point of a de tected digital image through control of a current

applied to the object ive lens by adding an offset 112, a loader 116 (not

shown) for loading the wafer 31 from its cassette 114 to the specimen

chamber 107 and unlo ading the wafer 31 from the specimen cha mber 107

to the cassette 114, an orientation flat detector 117 (not sh own) for

positioning the wafer 31 according to the circumferential shape of the

wafer 31, an optical microscope 118 for allo wing observation of a pattern on the wafer 31, and a standard specimen 119 which is set on the stage 6.

Operations in the thir d preferred embodimen t are described below, which include a conditioning operation in which feature quantity data 250 and an image pro cessing condition 201 thereof are set up and an inspection operation in which pattern defects 11 are detected.

In the conditioning operation, the user opens the startup screen shown in FIG. 9 on the operation display 45. On a slot selection part 130 of the startup screen, the user selects a code number of a slot where the wafer 31 to be ins pected is contained. Then, on a recipe selection part 131, the user spe cifies a product type of the wafer 31 and a process step thereof, and th e user presses a reci pe creation start bu tton 132 for starting the conditioning operation. The conditioning operation includes; contrast setting for the electro n optical system 106, pattern layout setting for the wafer 31, pattern positioning alignment for the wafer 31, calibration in which a signal lev el of the wafer 31 is checked at a position where the signal level is indicated accurately, inspection condition setting, image processing feat ure quantity data set ting 253 for specifying feature quantity data 250 and an image processing condition 201 thereof, and setu p condition check in trial inspection. Described below are the contras t setting, image proc essing feature quanti ty data setting, and trial inspection, which form essential parts of the present invention.

The general control part 110 provides operational instructions to each part in the following manner. First, the general control part 110 issues an operational instruction to the loader 116 (not shown) so that the loader 116 takes the wafer 31 out of the cassette 114. Then, through the use of the orientation flat detector 117 (not shown), the circumferential shape of the wafer 31 is checked, and the wafer 31 is positioned according to the result of this check. The wafer 31 is then mounted on the stage 6, and the specimen chamber 107 is evacuated. Simultaneously, the electron optical system 106 and the retarding voltage 108 are conditioned. A voltage is applied to the blanking plate 104 to turn off the electron beam 2. The stage 6 is moved so that the standard specimen 119 can be imaged, and an output of the Z sensor 113 is made effective. While a focal point of the electron beam 2 is maintained at a position corresponding to "a value detected by the Z sensor 113 + an offset 112", raster scanning is performed by the deflector 105. In synchronization with this raster scanning, the voltage applied to the blanking plate 104 is turned off so that the wafer 31 is irradiated with the electron beam 2 as required. Backscattered electrons or secondary electrons produced from the wafer 31 are detected by the detector 8, which then outputs a detected analog signal. Through the A/D converter 9, the detected analog signal is converted into a digital image. By changing the offset 112, a plurality of digital images are detected, and in the general control part 110, an optimum offset 111 for maximizing the sum of image differential values is determined. The optimum offset

111 thus determined is set up as the current offset value. After the optimum offset 111 is established, the output of the Z sensor 113 is made ineffective and a screen transition is made to a contrast adjustment screen such as shown in FIG. 10. The contrast adjustment screen comprises: a map display part 55 having a map display area, a button for controlling display of the entire wafer or die map, and a mouse operation command button 140 for controlling position movement or item selection by the use of the mouse 121 (not shown); an image display part 56 having an image display area and an image changeover button 141 for setting an image magnification, selecting an optical micrograph image attained through the optical microscope 118 or a SEM image attained through the electron optical system 106, and specifying a kind of image; a recipe creation item selection button 142; a recipe creation end button 133; and a recipe save button 134.

On the contrast adjustment screen, the user sets the mouse operation command button 140 to a movement mode, and performs movement on the map by clicking the mouse 121 to view an image at the current position on the image display part. Then, the user assigns an adjustment item of the electron optical system 106 to the knob 122, and adjusts each part of the electron optical system 106 to attain proper contrast. The recipe creation end button 133 is used for terminating recipe creation, the recipe save button 134 is used for saving recipe condition data, and the recipe creation item selection button 142 is used for setting another condition and issuing an instruction for screen transition.

These buttons are available on all the screens. To open a trial inspection initial screen such as shown in FIG. 11, the user sets the recipe creation item selection button 142 to a trial inspection item.

The trial inspection initial screen comprises a map display part 55, a recipe creation end button 133, a recipe save button 134, a recipe creation item selection button 142, an inspection start button 143, and an inspection end button 144. The user sets the mouse operation command button 140 to a selection mode. Then, by clicking a die on the map display part 55, the user can select/deselect the die for trial inspection . Each die can thus be selected for trial inspection. After selecting any die for trail inspection, the user presses the inspection start button 143 to start trial inspection. When trial inspection is started, the stage 6 is driven for movement to a scanning start position of the region to be inspected on the wafer 31 mounted thereon. A pre-measured offset value inherent in the wafer 31 is added to the offset 112, and the Z sensor 113 is made effective. Then, along the scanning line 33 shown in FIG. 3, the stage 6 is scanned in the Y direction. In synchronization with this stage scanning, the deflector 105 is scanned in the X direction. During a period of effective scanning, a voltage to the blanking plate 104 is turned off to let the electron beam 2 fall on the wafer 31 for scanning the surface thereof. Backscattered electrons or secondary electrons produced from the wafer 31 are detected by the detector 8, and through the A/D converter 9, a digital image of the stripe region 34 is attained. The digital image thus attained is stored into the memory

109. After completi on of the scanning operation of the stag e 6, the Z sensor 113 is made ineffective. The entire region of inte rest can be inspected by repe ating stage scanning . In cases where the entire surface of the wafer 31 is inspected, a scanning sequence shown in FIG. 12 is taken.

When the detection po sition A 35 is taken in the image processor circuit 10, an image attained at the detection position A 35 is compared with an image attain ed at the detection position B 36, which has been stored in the memory 109. If any differ ence is found in com parison, the difference is extr acted as a candidate defect 40 and feature quantity data 203 of the candidate defect 40 is stored into the candidate defect memory part 41. Simu ltaneously, at the feature quantity data check part 251, it is checked whether the candidate defect 40 meets prespecified feature quantity data 250 or not. If the candidate defect 40 meets the prespecified feature quantity data 250, data of the candidat e defect 40 is sent to the det ail image processing part 252. Then, in the detail image processing part 252, image processing is carried out under an image processing condition 201 determined for each prespecified feature quantity data to check whether the candidate defect 40 is a pattern defect 11 or not. If the can didate defect 40 is recognized as a patter n defect 11, an identification code 253 thereof stored in the candidate defect memory part 41 is sent to the general control part 110. After completion of inspection of the entire region of int erest, a defect chec k screen such as shown in FIG. 19 is opened.

The defect check scre en comprises a defect display editing part 150 for displaying feature quantity data of defects and editing classification thereof, a map display part 55 in which a current position indicator 59 indicating the current position and class code symbols of pattern defects 11 are displayed on a layo ut of the wafer 31, an image display part 56 in which an image taken at the current position is displayed, a real/memory image display changeover button 255 for making a cha ngeover between real image display and memory image display, and other buttons which have already been described. The user sets the mouse op eration command button 140 to the selection mode , and then clicks any pattern defect 11 indicated on the map display part 55. Then, if re al image selection has been made with the real/me mory image changeove r button 255, a coordinate loc ation of the pattern defect 11 is taken fo r image acquisition. If memo ry image selection has been made with the real/memory image changeover butt on 255, an image of the pattern defect 11 is pr esented on the image display pa rt 56 and feature quant ity data thereof is pre sented on the defect display editing part 150. On the defect display editing part 150, the pattern defect 11 is subjected to classification according to the image and feat ure quantity data th ereof, i.e., a class code is assigned to the featu re quantity data of the pattern defect 11. At this step, if it is desir ed to treat th e patt ern defect 11 as a de fect not to be detected 58, a particular class cod e is assigned thereto . Thus, it can be identified as a defect not to be detected on the map display part 55. After compl etion of the defect cl assification, the use r makes

a transition to an image processing feature quantity data setting screen
260 shown in FIG. 20 using the recipe creation item selection button,
or the user returns to the trial inspection initial screen by pressing
the inspection end button.

The image processing feature quantity data setting screen 260
comprises a class code specifying part 262 for specifying a class code
of interest 261, a defect selection part 263 for selecting defects having
the class code of interest 261 in succession, a feature quantity data
specifying part 264 for specifying feature quantity data of each selected
defect and feature quantity data 250 used as a selection criterion, a
map display part 55, an image display part 56 in which an image of each
defect 11 is displayed, an image processing condition setting part 265
for setting up an image processing condition number 207 corresponding
to an image processing condition 201 to be applied to an image selected
by the feature quantity data specifying part 264, a defect redisplay
button 207 for indicating on the map display part 55 the result of judgment
attained after an evaluation image processing part 252 checks whether
or not an image in the candidate defect memory part 41 is a pattern defect
11, a new feature quantity data creation button 266 for creating a new
image processing condition number 207 corresponding to presp ecified
feature quantity data 250, a completion button 161 for indicating the
end of creation of new feature quantity data, and other buttons which
have already describe d. The recipe save button 134 is provided for saving
data in a recipe.

After saving the data, the user presses the completion button 161 to return to the trial inspection defect check screen. Further, on the trial inspection defect check screen, the user presses the inspection end button 144 to return to the trial inspection initial screen. Then, it is also allowed for the user to select another die for trial inspection. For confirming and terminating the above-mentioned session, the user presses the recipe creation end button 133. Upon completion of the recipe creation, the wafer 31 is unloaded back to the cassette 114.

The following describes the inspection operation. In the inspection operation, the user opens the startup screen shown in FIG. 9 on the operation display 45. On the slot selection part 130 of the startup screen, the user selects a code number of a slot where the wafer 31 to be inspected is contained. Then, on the recipe selection part 131, the user specifies a product type of the wafer 31 and a process step thereof, and the user presses an inspection start button 330 for starting the inspection operation. After wafer loading, alignment and calibration are made, inspection processing is carried out. Then, defect check and defect data output are performed, and wafer unloading is made at the end of inspection. Described below are the inspection processing and defect check, which form essential parts of the present invention.

When the user presses the inspection start button 330 to indicate the start of inspection, the stage 6 is driven for movement to a scanning start position of the region to be inspected on the wafer 31 mounted

thereon. A pre-measu red offset value inhe rent in the wafer 31 is added to the offset 112, an d the Z sensor 113 is made effective. Then, along the scanning line 33 shown in FIG. 3, the stage 6 is scanned in the Y direction. In synchronization of this stage scanning, the deflector 105 is scanned in the X direction. During a period of effective sc anning, a voltage to the blanking plate 104 is turned off to let the electron beam 2 fall on the wafer 31 for scanning the surface thereof. Backscattered electrons or secondary elec trons produced from the wafer 31 are detected by the detector 8, and through the A/D converter 9, a digital image of the stripe region 34 is attained. The digita l image thus attained is sto red into the memory 109. After completio n of the scanning operation of the stage 6, the Z se nsor 113 is made ineffective. The entire region of in terest can be inspecte d by repeating stage sc anning. In cases where the entire surface of the wafer 31 is inspected, the scanning sequence shown in FIG. 12 is taken.

When the detection po sition A 35 is taken in the image processor circuit 202, an image attained at the detec tion position A 35 is compared with an image attain ed at the detection position B 36, which has been stored in the memory 109. If any differ ence is found in com parison, the difference is ext racted as a candidate defect 40 and stored in the candidate defect memory part 41. Furthe r, the feature quantity data check part 251 selects a candidate defect meeting the prespecified feature quantity data, and using an image processing condition 201 determined by an image process ing condition numbe r 207 corresponding to the

prespecified feature quantity data, the detail image processing part 252 forms a judgment on whether or not the candidate defect 40 is a pattern defect 11 to prepare a list of pattern defects 11. The list of pattern defects 11 thus prepa red is sent to the gen eral control part 110 . After completion of inspect ion of the entire regi on of interest, a defe ct check screen such as shown in FIG. 15 is opened.

The defect check scre en comprises a defect display editing part 150 for displaying feature quantity data of defects and editing classification thereof, a map display part 55 in which a current position indicator 59 indicating the current position and class code symbols of pattern defects 11 are displayed on a layo ut of the wafer 31, an image display part 56 in which an image taken at the current position is displayed, a display changeover button 151 for turn ing on/off candidate defects 41 with pattern defec ts 11 indicated, and an inspection end but ton 144 for indicating the en d of inspection. The user sets the mouse op eration command button 140 to the selection mode , and then clicks any pattern defect 11 indicated on the map display par t 55. Thus, an image of the pattern defect 11 is presented on the image display part 56, and feature quantity data thereof is presented on the defect display editing part 150. On the defect display editing part 150, the pattern defec t 11 is subjected to classification according to the image and feature quantity data thereof, i.e., a class code is assi gned to the feature quantity data of the pattern defect 11. A display cha ngeover button 209 is provided for turning on/off the display for the image processing condition 201

in the image processing region 200. With this button, the user can perform a display changeover according to whether or not the image processing condition 201 is appli ed to each pattern def ect 11 in the image pro cessing region 200. If, by using the special cond ition on/off button 208, the user has specified tha t the image processing condition 201 is to be applied at the time of inspec tion, a display chang eover with the image display changeover button 209 is not available since the image processing condition 201 is alre ady applied. To term inate the inspection defect check session mentioned above, the user presses the inspection end button 144. Each classified pattern defect 11 and feature quantity data thereof are stored into memo ry means (not shown) in the general cont rol part 110, and also delivered to external memory means (not shown) through a communication line (not shown) or to other inspection/observation means (not shown). Then, control is returned to the initial screen.

According to one aspe ct of the third prefe rred embodiment, the entire surface of each wafer can be inspected using a SEM image thereof to detect true patte rn defects 57 only. Thus, the user can identify the true pattern defects 57 with ease.

Further, according to another aspect of the third preferred embodiment, in cases where rough patternin g is made to form a re dundant power wiring layer or a pattern edge, a degr ee of roughness in pat terning can be examined by means of display changeover.

Still further, accord ing to another aspect of the third preferred embodiment, an image processing condition can be set so that false defects

identified under actual inspection conditions will not be detect ed. It is therefore possible for the user to speci fy a threshold proper ly just as required.

Furthermore, according to another aspect of the third preferre d embodiment, the image processing condition 201 is adjustable without completely deleting data of pattern defects 11 in the image pro cessing region 200. Therefor e, the user can adjust the image processing condition 201 so that false def ect detection will be prevented as require d while possible defects remain inspectable.

As set forth hereinab ove and according to the present invention, the user can set up a non-inspection region effective for a devic e having a complex, large patt ern area to be inspect ed such as a wafer. Further, in cases where a co nsiderable difference is found in compa rative inspection of detected images even if the difference is not actually a defect, the present invention makes it possible to avoid fals e defect detection while carrying out detection of minuscule defects.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics there of. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the sc ope of the invention being indicated by the appended claims rather than by the foregoing description and all changes which come within the mean ing and range of equi valency of the claims are therefore intended to be embraced therein.